TELECONFERENCED GROUP DECISION MAKING:

DESIGNING FOR IMPROVED PERFORMANCE

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PART I

CONTENTS

TELECONFERENCED GROUP DECISION MAKING: DESIGNING FOR IMPROVED PERFORMANCE

1. AIMS AND OBJECTIVES

1.1 Beyond Meeting Substitution

This project is concerned with trying to get the best out of teleconferencing. It forms part of a broader program of research by DARPA to build a personal communication system to link members of the government executive and the military command at times of national emergency when it may be inopportune or inadvisable to have all the contributors to decision making in one place.

The teleconference, that is generically systems which permit groups of people to hold meetings even when geographically separated, has been the subject of research, speculation and pronouncement within the broader field of office automation and business efficiency for more than a decade. Arriving from such a perspective, the concern of this activity has been to show that use of teleconferencing can reduce business operating costs, or save national energy, without having too many damaging effects on the progress and outcome of meetings that would presumably otherwise have been held in the orthodox 'round-the-table' manner.

But to view teleconferencing simply as a cheaper substitute for normal meetings is to greatly undervalue its potential. Many commercial and governmental users of teleconference systems and services have grown to recognize its broader value in their organizations' communications. Added values include making it possible to keep people informed and up-to-date without the burden of regular business travel, and increasing the flexibility of holding meetings in terms of set-up time and the number and nature of the people involved. Despite this enlightenment amongst experienced users, the conduct of each actual teleconference has tended to stay close to the model of the face-to-face meeting, with no explicit attempt to further extend the benefits of teleconferencing. In the course of the research reported here, and in discussions with users, researchers, and implementers of teleconferencing, it has become increasingly apparent that the conduct of teleconference meetings can offer gains within the meeting itself over and above the way that the meeting would have been conducted face-to-face.

The impetus for the line of enquiry represented by this report, was given in a paper by Dr. Craig Fields at a Nato conference on the subject of teleconferencing held at Bergamo, Italy in October 1977. The theme of the paper was that meetings held face-to-face were not always so wonderful that we would want to recreate them in teleconferences. Instead the separation of the participants, and the opportunity to interpose in the transmission-line with various technical capabilities, could be used to rid teleconferences of the sorts of problems that are known to interfere with effectiveness of face-to-face meetings. Dr. Fields himself suggested 13 examples of what he meant, including capabilities such as translation of jargon and technical terms.

Following the objective of DARPA to mount a research program aimed at designing and building a teleconference system to be used at the highest level of decision making, the principle of developing teleconferencing to overcome the problems of face-to-face meetings was revised. Communications Studies and Planning Ltd., a company with unparalleled experience in the fields of research, design and evaluation of teleconference systems, was approached by DARPA to submit a proposal for research as part of the teleconference program. The proposed research was to use teleconferencing to improve group decision making.

1.2 Lessons from Prior Teleconference Research

As has been already indicated, the existing research on tele-conferencing took a conservative approach in assuming that any major variations in outcomes when meetings were held by teleconference, in comparison with similar meetings held face-to-face, would be negatively viewed and such meetings would be deemed to be unsuitable for conduct via teleconferencing. Hence certain activities prevalent in meetings were held to be easily transferable to a teleconference medium (e.g. exchanging information and generating ideas), while others were considered to be unsuitable for this type of interaction (e.g. negotiating and resolving conflicts). Whereas these conclusions are worthy of consideration in the planning of a commercial teleconference network, they are inappropriate for the purposes of this study, which should address just such issues of conflict resolution in decision making via teleconference.

The recommendations that meetings involving conflict and negotiation were not suited to teleconferencing were based on a research paradigm of two people set to discuss issues on which they had opposing views, the discussions being held in one of three conditions: face-to-face, between separate rooms linked by audio-only or audio and closed-circuit television links. The two latter conditions were used as simulations of teleconferencing. The nature of the differences found were:

- Tasks involving changing the opinion of the other person produced more movement toward agreement in the teleconference condition than the face-to-face condition.

- Tasks involving negotiation concentrated more heavily on the issues involved, rather than on the people holding the discussion, in the teleconference condition. The side with the strongest case was more likely to win the negotiation when the meeting was in the teleconference condition.

- These effects of teleconferencing were most marked for the audio-only teleconference condition.

These findings are often quoted in teleconference research for their value as that rare phenomenon in social research, a counter-intuitive result. When presented as bare statements they may be accepted as reasonable, but most people when discussing the applications of teleconferencing state that if they wanted to persuade another person on some matter, they would always prefer to do so face-to-face. They would now be advised to do so only if they had a weak case to argue and a strong charisma!

In a situation of decision making at times of national crisis it would be hoped that decisions would be based on strong arguments and facts rather than the charismatic qualities of one of the protaganists. Hence the use of teleconferencing at such a time may in itself have value. Similarly, users of teleconferencing in both laboratory simulation studies and real systems in the field, report that meetings held by teleconference are more rapid, more business-like, and less likely to stray off the intended subjects. This reinforces the impression of a concentration on issues rather than on personal power games and the other "hidden agendas" that constitute many formal meetings in business and government.

## 1.3 Research to Enhance Teleconference Group Decision Making
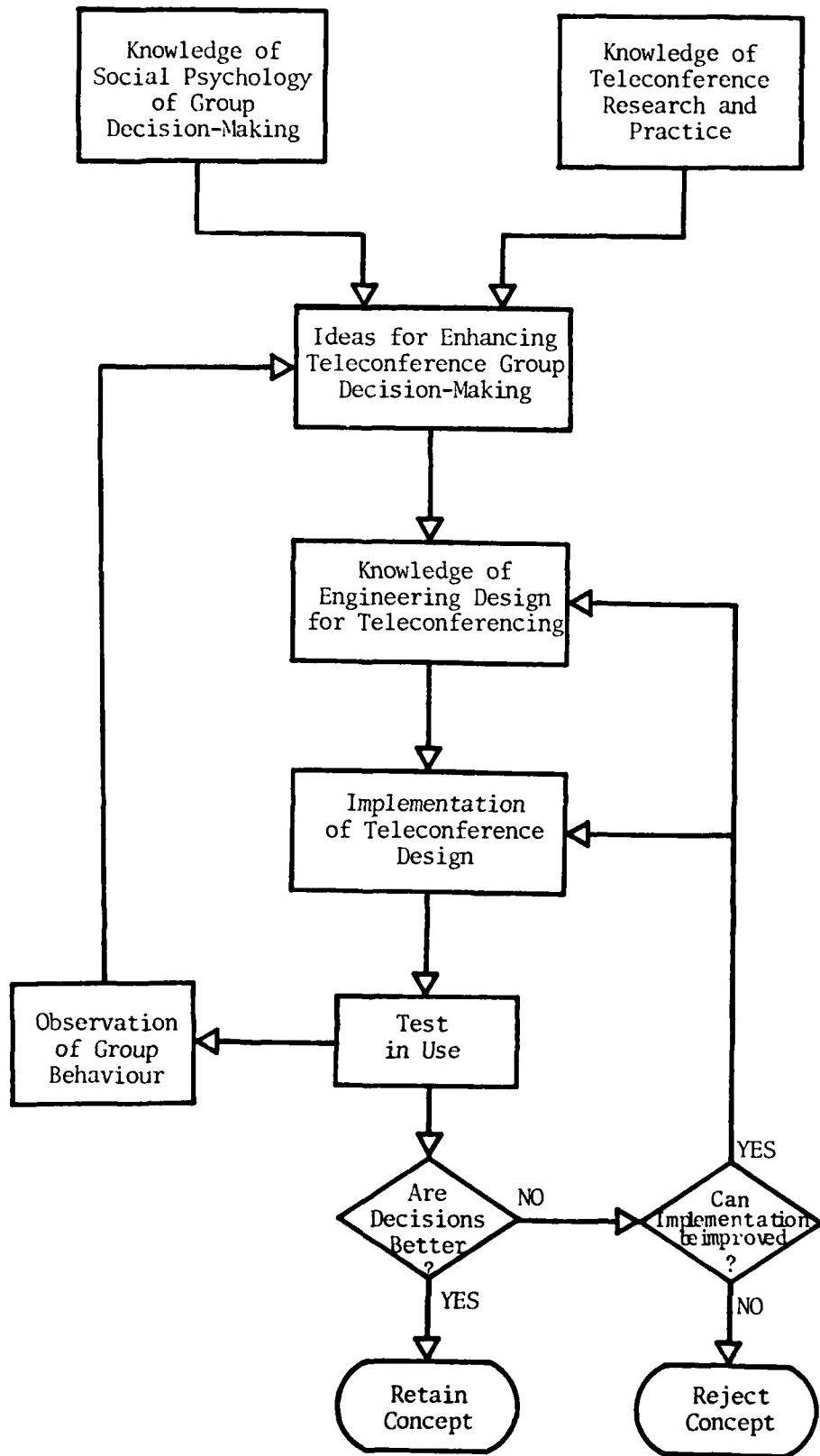
With the starting point that teleconferencing in its own right may
be advantageous for improving meetings involving negotiation and
conflicting ideas, the research undertaken here was directed toward
extending these advantages. Drawing on the research literature not only
of teleconferencing, but also of the social psychology of group
decision making, it was to develop, implement, and evaluate ideas for
enhancing group decision making. Four such ideas were put forward in the
research proposal (ARPA/79107/YN):

- facility to hold private side conversations
- facility to put forward ideas at the time of thought
- facility to put forward contributions anonymously
- use of support staff to provide services such as information
  retrieval.

The rationale for these ideas and facilities is presented in detail in
the proposal document. They were all seen as ways of overcoming the types
of problems that were thought to impede successful group decision making.
The overall aim of the research, however, was not restricted to the
straightforward assessment of the contributions to decision making of
these four concepts. In addition it was anticipated that new ideas and
concepts would be developed in the light of the experience gained in the
research. Figure 1.1 shows a simplified flow-chart of the planned
progress of the research.

The first stage was to design and implement a working teleconference
system that would be flexible enough to incorporate not only the ideas
put forward in the proposal, but further initiatives developed in the
course of the research. The basic design in itself should be consistent
with the intention of overcoming the types of problems found in
face-to-face meetings. The second stage was to test out the concepts
proposed to see what value, if any, they had for improving group
decision making. It will be noted from Figure 1.1 that the testing stage
had two outputs: one concerned specifically with testing individual
concepts; and the other a learning process by which new ideas and
concepts could be generated and fed into the research process at an
earlier step.

FIGURE 1.1

The keynote of the research strategy was flexibility. The flexibility of the teleconference system to modification and expansion, and the flexibility in testing procedures to take up a new direction. The use of a traditional experimental design was not considered to be appropriate. Within such a design, equal numbers of groups of teleconference participants would have held the same simulated meeting under a teleconference condition that was controlled by the researchers. Once set in motion, such a research design must be carried through to its conclusion, or the value of the design is lost. If a proposed decision making enhancement technique had been found to be not used at all by groups to whom it was made available, this state of affairs would have been tolerated and left unchanged throughout the research. By comparison the research strategy adopted here would have investigated why the facility was not being used. If the answer lay in poor implementation, then alternative ways would have been considered, whereas if the concept was just not a valuable contribution then no further time and effort would be wasted on it.

The research strategy adopted in the early phases placed far heavier emphasis on the reactions of users of the teleconference system and decision making enhancement facilities than on traditional research methodology. The main aim at this early phase was to have as many people use the system as possible, thereby exposing any weaknesses and failings, as well as generating new ideas. For this to be successful the users and the uses had to be appropriate. Users were primarily middle and senior management in a variety of businesses and government activities who had been recruited from the central London area (a fuller description is contained in Annex B). They were invited in groups of four to attend experimental sessions of teleconferencing at the offices of CS&P Ltd. in central London, where they either took part in a discussion task set as part of the research program, or held their own discussions. Following the teleconference discussions, usually lasting between 45 and 60 minutes, participants took part in a debriefing discussion with one or more members of the research team. These debriefing discussions, usually held while offering the participants suitable refreshments, were a major source of information, not only on the teleconference system as tested but also on other ideas not yet implemented. By using experienced managers used to the ways and means of face-to-face meetings, implicit comparisons could be made with their normal meeting experiences.

In addition to these evaluation sessions with outside participants, the teleconference system was also used on a regular basis by members of the research project team, for the purpose of progress meetings, and by visitors to CS&P Ltd.. Among the visitors were included several people with extensive experience of teleconferencing. These two additional types of use and user provided inside information and critical evaluation which cannot be gained from the role of the detached experimenter. A full list of organizations who took part in one form or another of the system trial is shown in Annex B.

The framework of the research during this phase of the project, was to explore in turn the value of each enhancement concept, as far as proved to be worthwhile. The sequencing of the introduction of each concept was determined, at least in part, by the gradual build-up of the technical capability of the equipment. Some sessions provided no enhancement facilities, to give a basis for comparison. In addition to the information gathered during the debriefing sessions, which helped to shape the research, more formal data was collected by using simple questionnaires at the end of each experimental session, and from the outcomes of the prescribed experimental tasks.

The tasks used in this phase were developed to meet criteria that they should:

- be non-trivial,
- draw on the knowledge and experience of the participants plus supplementary information,
- be easily and readily understood,
- induce involvement and motivation to make the best possible decisions,
- have outcomes evaluable against some external criteria.

Further information on the tasks used is contained in part 2 of the report and in Annex B.

Later in the project the teleconference system was used to hold extended internal meetings lasting in the first instance for a whole day and secondly over a one week period. These extended applications of teleconferencing were valuable both in the unique information provided

about the prolonged use of this form of interaction, and in the knowledge
they provided about group decision making enhancement. To the knowledge
of the research team, no previous research has looked at the impact of
prolonged teleconference interaction, but this information will be of
direct relevance to meetings held throughout periods of crisis.
Consequently the final phase of the project concentrated on getting more
information surrounding sustained use of the system. This time the
participants were specially recruited to hold a series of discussions via
the teleconference system, over a period of four days. During this final
phase, greater emphasis was placed on formal measurement and evaluation
than on the discussed opinions of the teleconference participants.

Throughout the project the research team worked toward three
priorities. These priorities are by no means incompatible with each
other, but on the few occasions when conflicts did arise between them,
they were pursued in the sequence:

- generate ideas for improving teleconference group de-
cision making;

- learn and understand the processes of group decision making;

- test and evaluate concepts for teleconference group
decision making enhancement.

1.4 Implications for the Design of a Teleconference System

The design of the basic teleconference system, as has been indicated
already, is the essential starting point for the research. Although
amendments and extensions to the system formed part of the project, the
general form of the system had to be correct in the first instance.
Chapter 2 of this report describes in some detail the teleconference
system as it was operating at the conclusion of the study, while
chapter 5 describes the ergonomic development of the system in the course
of the project. This section will not therefore duplicate those chapters,
but will discuss the philosophy underlying the teleconference design.

Three basic areas of consideration were taken on board at the design
stage:

- operational characteristics of the proposed DARPA tele-
conference system;

- the use of the basic teleconference system as a decision enhancement aid;

- the need for flexibility.

The first of these factors provided guidelines on which various decisions could be based. It was known that DARPA were concerned to build a video teleconference system that would operate under conditions of extremely restricted transmission bandwidth (100 kbit/s per sec for input and output at each conference site). The inclusion of a visual image of participants was considered to be necessary for reasons of confidence among the participants, though it was recognized that the bandwidth restrictions would only permit the use of low resolution images with limited grey-scale. Additionally it was known that only one person would need to be seen at each site, and that the number of sites involved in a conference could be in the range of 10-20 participants.

These characteristics determined that the experimental system should be multipoint audio-video whose layout could be extrapolated from the small experimental system (four conference nodes) to a larger real system. The visual image should be monochrome rather than colour, as colour would be superfluous to the needs and capabilities of the real system. And finally the design should be such that the signal information flow into and out of each node could be kept to a minimum. No attempt was made though in this project to simulate the type of video image compression that could be anticipated to occur in the final DARPA teleconference system.

The second set of considerations, that the teleconference design in itself should be an aid to decision making, meant that an attempt was made to compromise between the ease of use and 'naturalness' of the system, and imposing changes which could offer an improvement on normal face-to-face meetings. It was not the intention of the design to try to reproduce the feeling of a "round-the-table" meeting, since it was the shortcomings of such meetings that the research project was trying to be overcome. Instead, where possible, the design tried to overcome problems evident in face-to-face group meetings, by for example, making possible private exchange of remarks between any two members of the group. At the same time, teleconference participants should feel comfortable in their meetings and should not have to learn new skills to function effectively.

The third consideration, flexibility, meant building a system with a greater capacity for change than might be used in the course of the research. This included, for example, making all circuits switchable at one or more points.

1.5 Structure of the Report

The rest of the report is divided into three main parts. The first provides an overview of the project, a description of the teleconference system as it existed at the end of the project, a summary of the major findings and their implications, and new directions for extending the concept of enhancement. The three chapters covering these areas, together with this introductory chapter, are bound and presented separately. They contain all that the general reader of the report would want to know about the project.

The second part contains detailed findings on the various aspects of the research, and gives a more detailed description of the research methodology. It will be of interest to those readers concerned with the substantiation of the findings summarized in part one.

The third part contains the various annexes germane to the project, namely: descriptions of tasks and sources of teleconference participants, technical information on the teleconference system, summaries of non-experimental activities relevant to the research, and samples of the questionnaires and recruitment brochure.

2. THE VIDEO TELECONFERENCE SYSTEM

At the start of the project, the design of the basic teleconference system was generated both to satisfy the aims of the research and to be able to accommodate developments and extensions as use of the system progressed. For this reason the system underwent change during the course of the research project, as further prospective decision-enhancement aids were incorporated, or unhelpful facilities dropped. The teleconference system is thus to be seen as undergoing an evolution towards a more efficient form where group decision making is enhanced in terms of quality and duration of outcome, without undue complexity or excessive signal transmission.

The sequence and rationale for these changes are described and discussed in chapter 5 of this report. What this current chapter aims to do is describe in non-technical terms, how the teleconference system operated at the conclusion of the project. The description is kept brief, but will be sufficient to permit general discussion of the research results.

2.1 General Physical Layout

For the research project a 4-point teleconference system was constructed in five adjacent rooms: one for each of the participants and a teleconference "controllers" suite. In this respect the arrangement simulates the geographical separation that would normally be a feature of meetings that compels some form of teleconferencing. The use of rooms in one location, however, makes the video links vastly simpler and easier to implement as well as making the interpolation of debriefing sessions highly efficient.

The participants' rooms were not identical: only two had windows, one room was larger than the rest and contained a spare desk. There were also differences in lighting, ventilation, decor and so on. The overall layout of the rooms and adjacent areas is shown in Figure 2.1. The teleconference equipment that was installed for the research, however, was identical vis-a-vis the arrangement of microphone, video monitors, loudspeakers and control panel, which were positioned as shown photographically in figures 2.4 and 2.6, and schematically in figures 2.2 and 2.3.

FIGURE 2.1   LAYOUT OF TELECONFERENCE ROOMS AND ADJACENT AREAS

(not to scale)
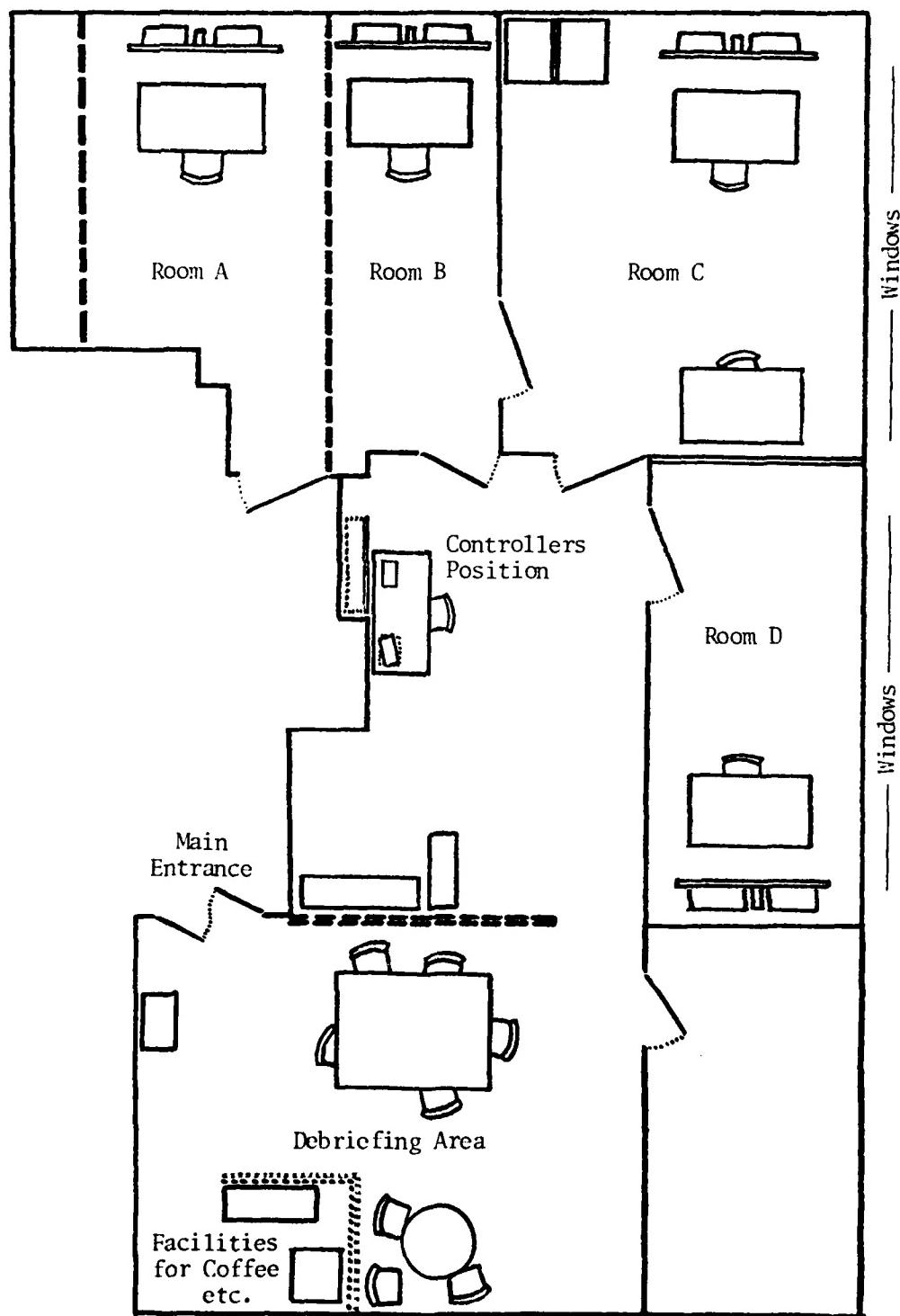
FIGURE 2.2   PLAN VIEW OF PARTICIPANTS TELECONFERENCE EQUIPMENT

Free standing Teleconference Unit
incorporating camera, monitors and loudspeakers

Microphone
Stand

Swan Neck
Microphone

Desk-top
Monitor

Audio-Video
Control Panel

Earpiece
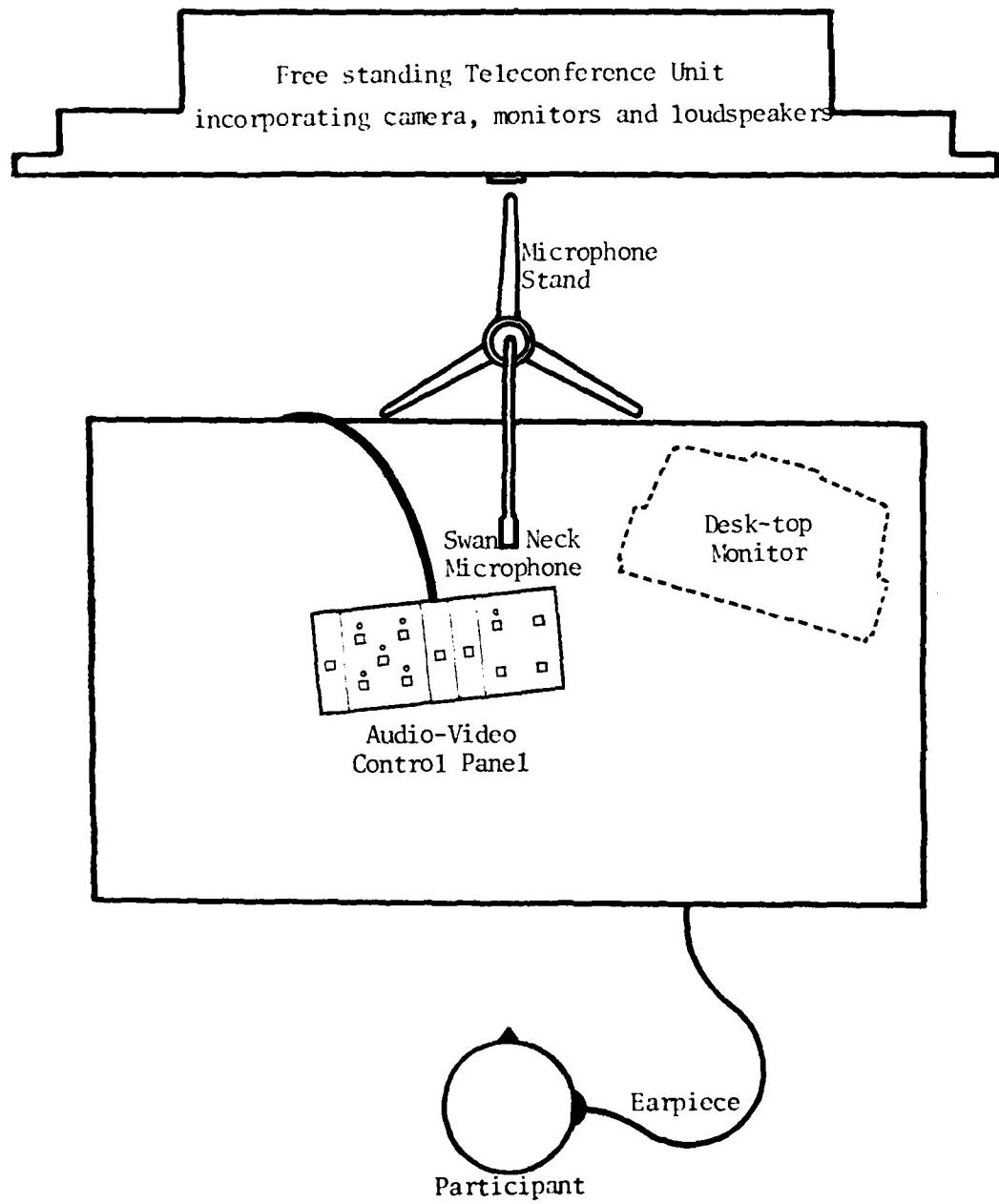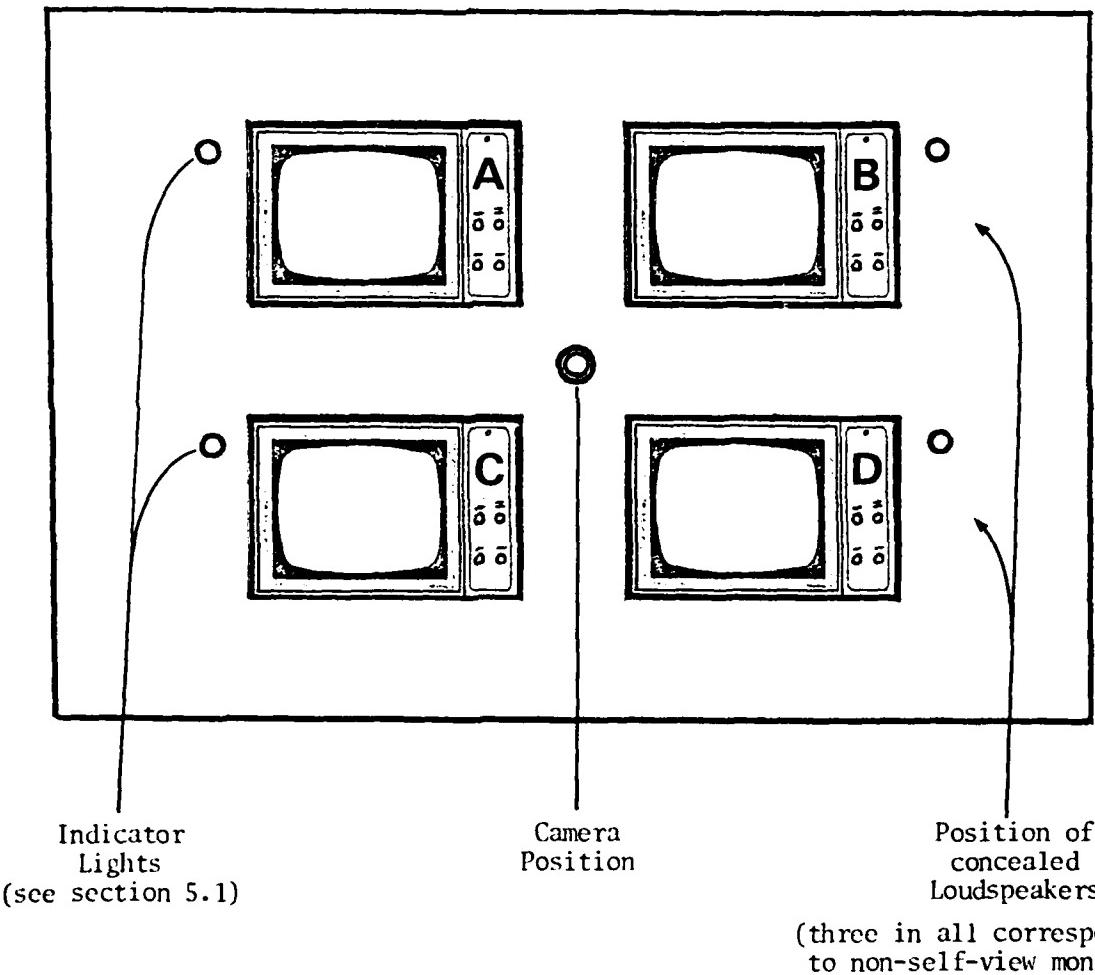
Participant

FIGURE 2.3   FRONT VIEW OF FREE STANDING TELECONFERENCE UNIT

Indicator
Lights
(see section 5.1)

Camera
Position

Position of
concealed
Loudspeakers

(three in all corresponding
to non-self-view monitors)
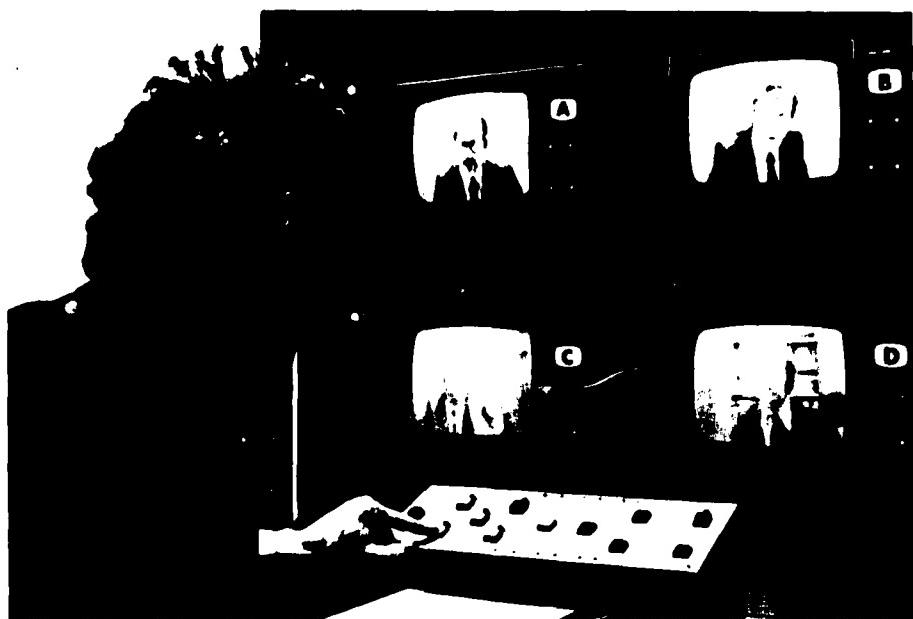
Figure 2.4

THE TELECONFERENCE
SYSTEM IN USE :

Participant B
initiates a private
call to C room.
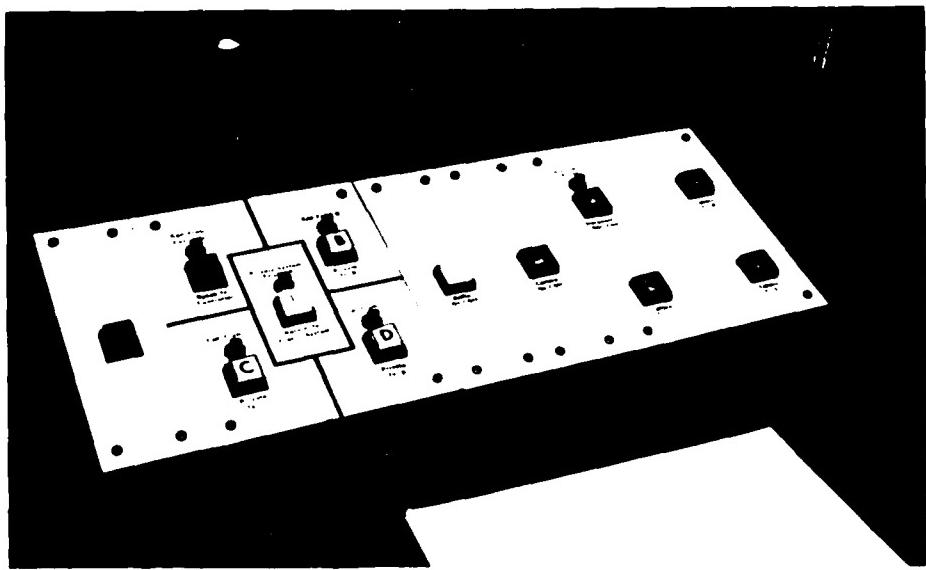
Figure 2.5

THE CONTROL PANEL
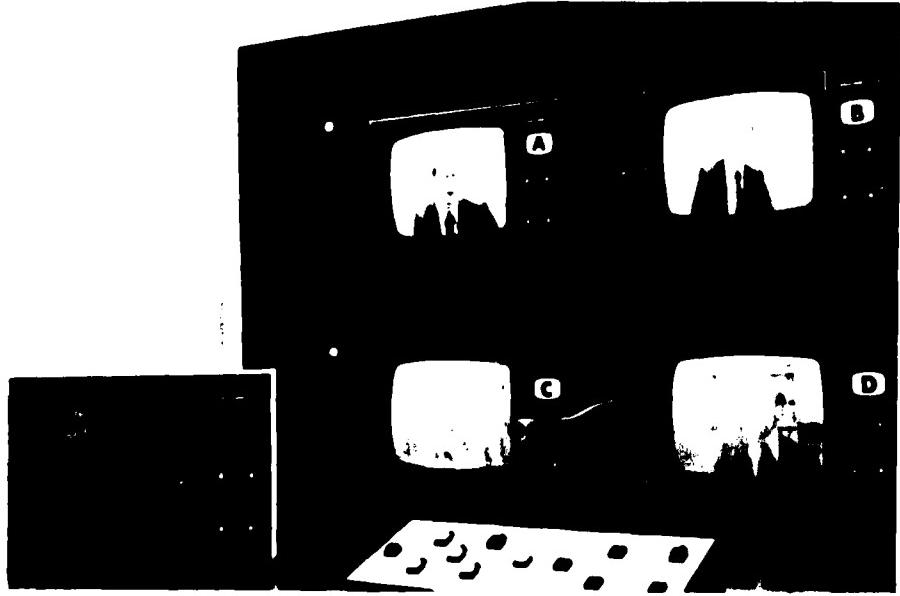
Figure 2.6

Another view
showing the
desk-top text/
graphics monitor.

Figure 2.7   THE CONTROLLER'S POSITION

(The video switching unit is at the top)
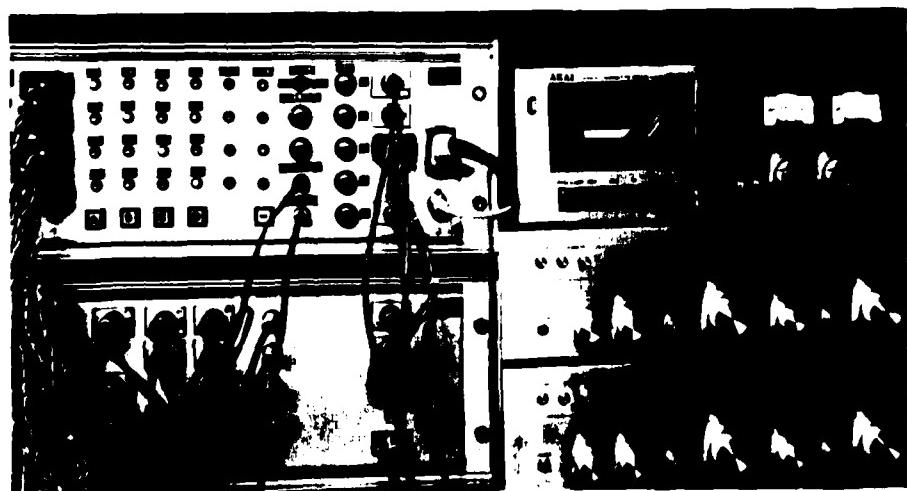
Figure 2.8   THE CENTRAL AUDIO EQUIPMENT
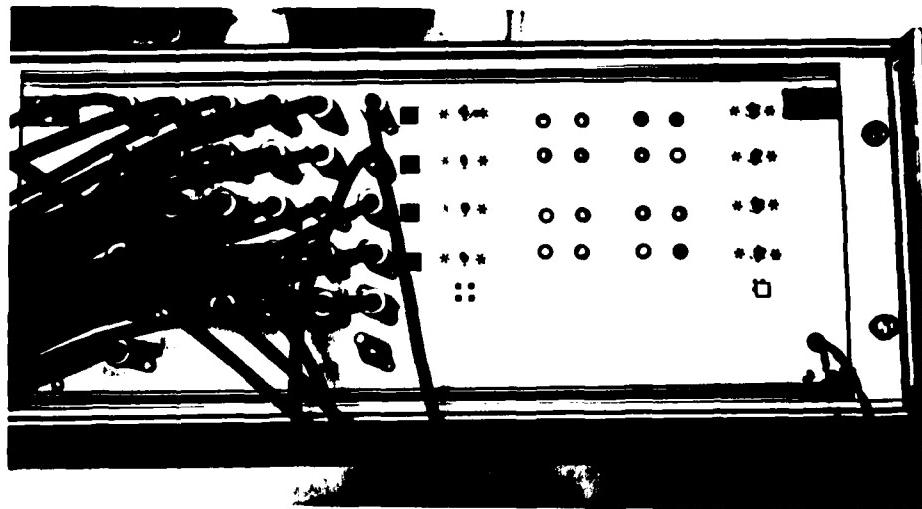
Figure 2.9 CLOSE-UP VIEW OF THE VIDEO SWITCHING UNIT
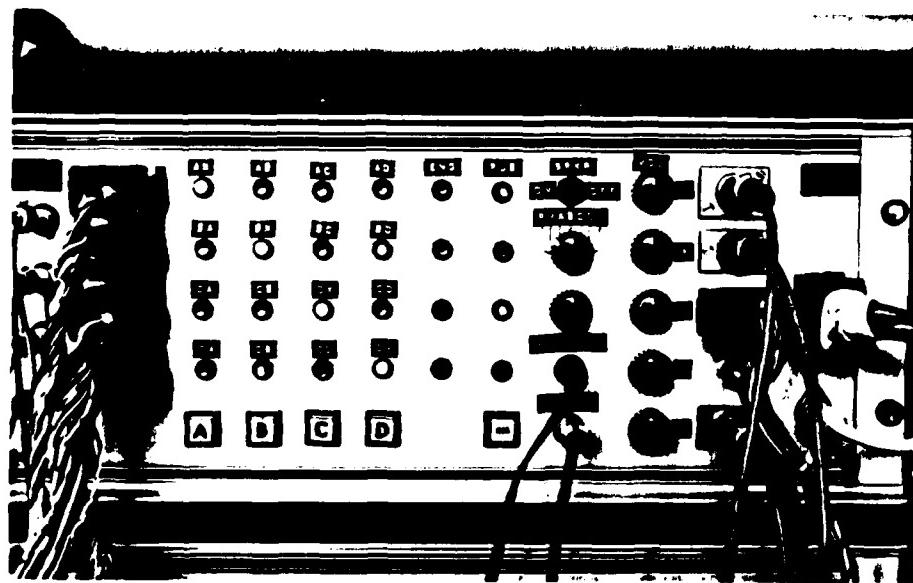
Figure 2.10 THE PRIMARY AUDIO SWITCHING UNIT

(The audio status lights show a private call
in progress between rooms B and D)

The central equipment at the controller's suite is connected to the four participants' rooms by concealed coaxial and multicore cables, to form a star network. The participants' teleconference units thus linked are:

- a closed circuit monochrome TV camera ⎤
- each of the four television monitors ⎬ Figure 2.3
- three loudspeakers ⎦

- a microphone ⎤
- an earpiece ⎬ Figure 2.2
- a control panel │
- an additional television monitor free-standing on the desk ⎦

The unrestricted panel gave individual participants command over both audio and video communication channels. Constructed in modular form, different combinations of functions could be offered to any participant. The operation and function of the panel pushbuttons are described in the relevant sections of this chapter.

The controller's position is shown in Figure 2.7. The heart of the equipment is the three large boxes of purpose built switching circuitry. The controller is not visible to the participants but can communicate with them by means of the private audio system (described in section 2.2.2).

2.2 The Sound System

2.2.1 Acoustics. A voice activated "capture" type of verbal exchange, with voice reproduction electronically delegated to the loudest microphone input, was eschewed in favour of an "open" audio system where all microphone inputs are simultaneously distributed. This is more transparent to the user and also avoids the unnatural "clipping" effect of interruptions.

An open audio system has some problems, however, since each microphone is "live" in a room where loudspeakers are reproducing the output from the other three. Too high a level of reproduction will initiate regenerative feedback or "howl around", and even somewhat below this threshold, speech is reproduced with a hollow, ringing quality.

In order to alleviate this instability and raise the available level of reproduction to a comfortable conversational volume, the following factors were considered in the design:

- Directional microphones were used facing away from the loudspeakers.

- The microphones were placed as close to the participant as possible, but not so close as to pick up breathing noise or incur volume variation with moderate head movement.

- Sound absorbing material was fitted where necessary in the experimental rooms in order to reduce the amount of reflected sound received at the microphone, but not so much as to unnaturally deaden the acoustic.
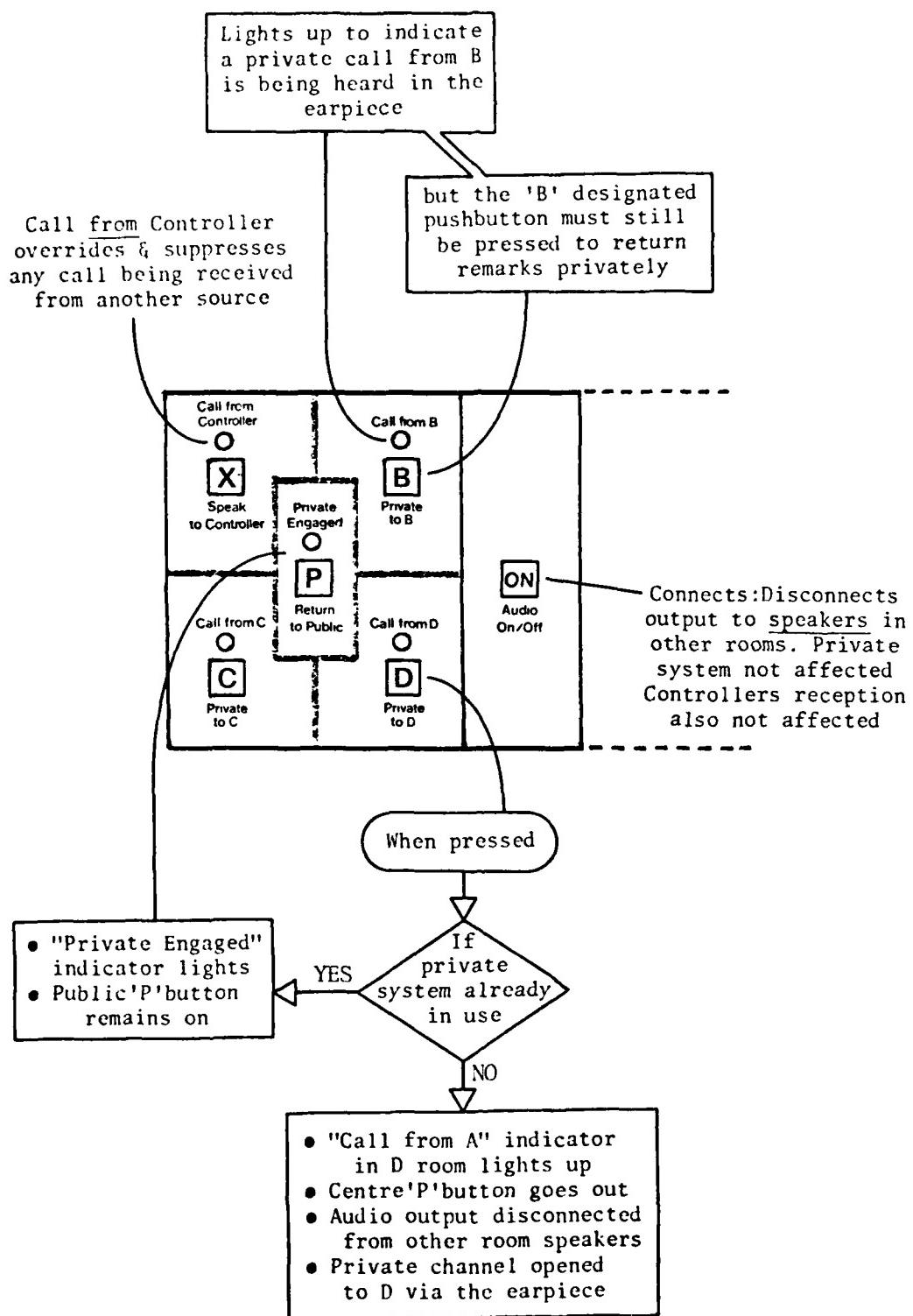
2.2.2 The private audio system. Provision was made in the design for private conversation between any two participants at a time. This facility was originally intended to be an occasional adjunct to the public discussion and if this open communication is to be maintained it is clear both that not more than two people can confer on the private system and that only one such dual link can occur at any time.

The operation of the private channel from the participant's point of view is described in Figure 2.11 and the accompanying text. A matrix of coloured indicator lights on the audio switching unit (Figure 2.10) notifies the controller of any calls or call attempts that are being made at any moment.

The following additional points not covered in the diagram notes are worth mentioning:

- When the "Audio On/Off" button is released, the person doing so ceases to hear the remaining public discussion over the room speakers.

- This does not occur when the private channel is in use, so that a participant may have to follow two conversations, but this is in accordance with the original idea of the facility.

- As may be seen from Figure 2.10, the controller has an "ALL" pushbutton that enables him to address remarks simultaneously to the earpieces of all four participants.

FIGURE 2.11   DETAILED FUNCTION OF AUDIO CONTROL PANEL

Lights up to indicate
a private call from B
is being heard in the
earpiece

but the 'B' designated
pushbutton must still
be pressed to return
remarks privately

Call from Controller
overrides & suppresses
any call being received
from another source

Call from Controller	Call from B
O	O
X	B
Speak to Controller	Private to B

Private Engaged
O
P
Return to Public

Call from C	Call from D
O	O
C	D
Private to C	Private to D

ON
Audio On/Off

Connects:Disconnects
output to speakers in
other rooms. Private
system not affected
Controllers reception
also not affected

When pressed

If private system already in use

YES

- "Private Engaged" indicator lights
- Public'P'button remains on

NO

- "Call from A" indicator in D room lights up
- Centre'P'button goes out
- Audio output disconnected from other room speakers
- Private channel opened to D via the earpiece

● Calls from the controller have an override priority such that
if, say, A and B are in private conversation when the
controller calls A, then the link from B to A is suspended
but B continues to hear A unless A chooses to return remarks
to the controller by pressing X.

2.3 The Video Design
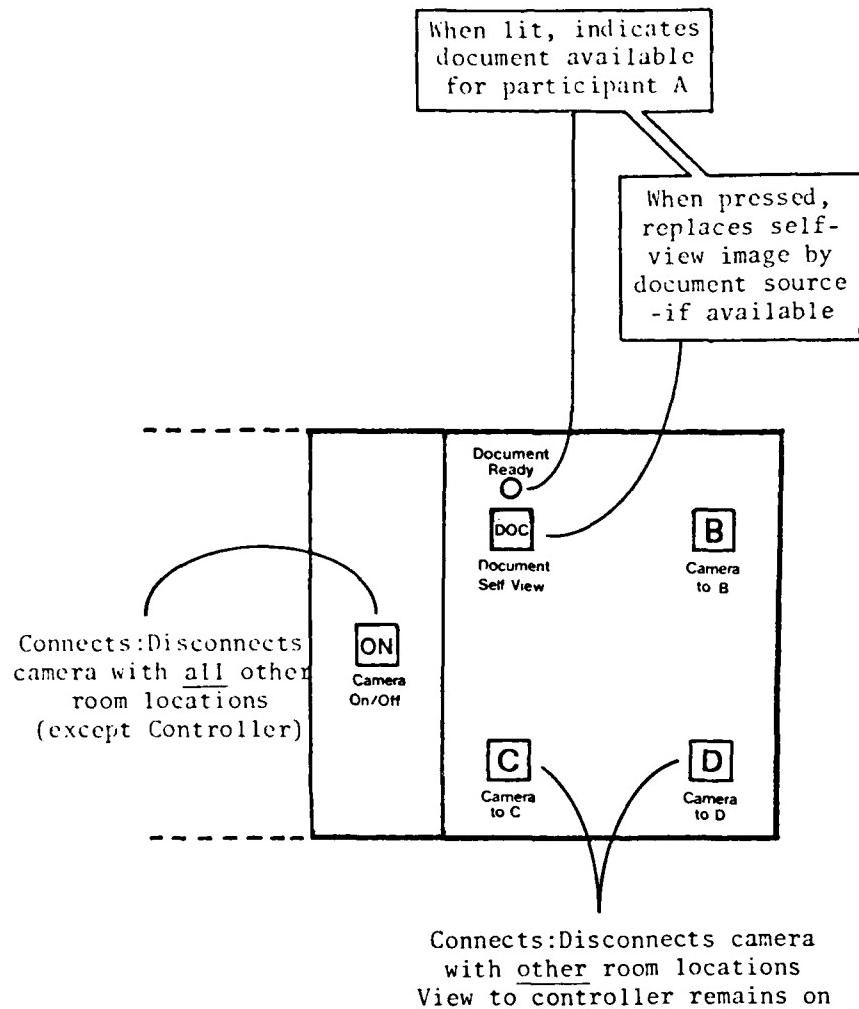
2.3.1 General considerations. Each participant's image is presented
on a 12" monochrome television monitor and four such monitor screens are
clustered around a central camera in a 2 x 2 array as shown in figure 2.3
Such a clustered arrangement was felt to be the best possible for a
4-point system for the following reasons:

● The distance between any two monitors is kept to a minimum so
that all participants can be held in the field of view
without undue head movement nor placing the monitor screens
too far away.

● Correspondingly, almost any camera arrangement will give
"side-of-the-head" shots to some participants if the angle of
view between monitors is too large.

● A single camera could be used, positioned at the centre of
the array and therefore equally adjacent to all four
monitors. (In an authentic teleconference situation where the
participants are geographically separated, this would
represent a significant economy and simplification for the
broadband video transmission between locations.)

● The arrangement has a high degree of symmetry and therefore
avoids unduly complicating the psychological research with
influences resulting from a participant being in a special
position, e.g. at the end of a linear row of monitors etc..

The configuration of monitors from room-to-room is consistent in the
sense that each viewer sees all four participants in the same
arrangement.

2.3.2 Video switching and "documents". The video switching buttons
on the participants' control panel function relatively simply. They are
in the same configuration as the monitors and each button switches the

FIGURE 2.12   DETAILED FUNCTION OF VIDEO CONTROL PANEL

When lit, indicates
document available
for participant A

When pressed,
replaces self-
view image by
document source
-if available

Document
Ready

DOC

Document
Self View

B

Camera
to B

Connects:Disconnects
camera with all other
room locations
(except Controller)

ON

Camera
On/Off

C

Camera
to C

D

Camera
to D

Connects:Disconnects camera
with other room locations
View to controller remains on

output from the camera in the room concerned to the appropriate monitor in the room designated on the button, thus enabling any participant to choose by which other participants he or she can be seen.

The orange pushbutton corresponding to the self-view position is used to switch that image over to the output from a source at the controllers position. This source was originally implemented as a "documents" camera but has also been driven by a microcomputer video output.

In addition, a separate, independent means of display is available as a fifth monitor link in each room. This is used as an alternative documents display on a desk top monitor placed slightly to one side of the participant (figures 2.2 and 2.6)

It was found that this utility is useful in 3 ways:
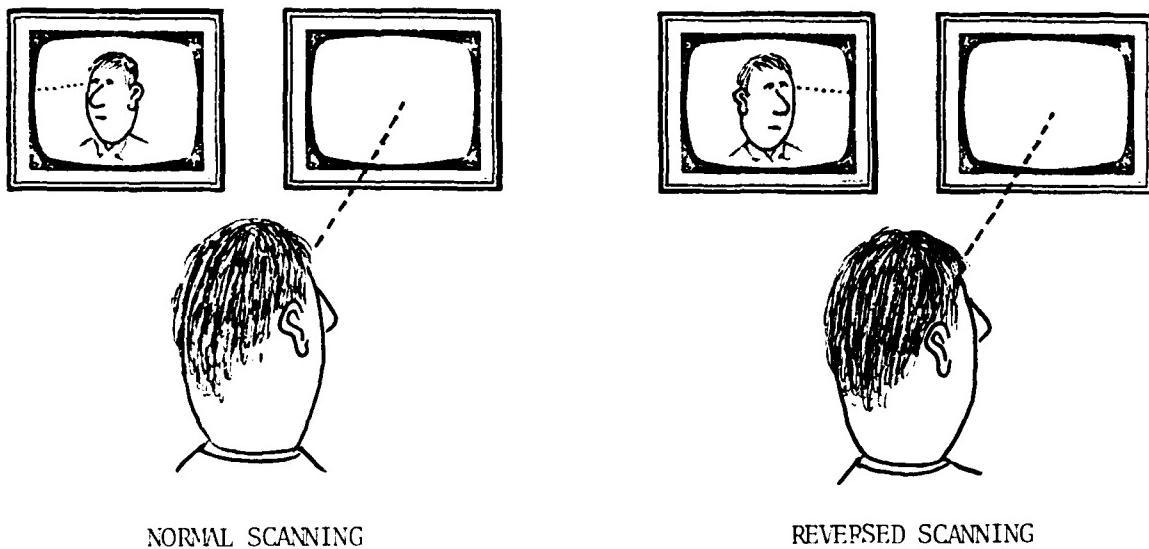
● The somewhat nearer position allows closer scrutiny of small print or fine details.

● Since the alternative methods are independent, two distinct information displays may be shown simultaneously.

● When for any reason, a fairly continual view of self-image is required, no conflict of priorities need occur when observing documents etc..

For maximum flexibility, all these "document" facilities are independently controlled, for each participant, by toggle switches on the video switching unit, (Figure 2.9) and when both utility channels are in use the two displays may be swapped over by this means.

2.3.3 Video image reversal. When the sessions were started it became rapidly apparent that it was necessary to reverse the horizontal scanning direction of each of the room cameras so that:

● All participants see mirror images of themselves on the self-view monitor rather than the actual view from the camera. The difference was quite conclusive - people are very familiar with their own mirror images but quite disconcerted when confronted with the apparently opposite movements of an unreversed self-view.

● The direction of gaze shown by the monitor image of a
participant became consistent with the direction they are
actually looking in. The following diagrams should make this
clear:

NORMAL SCANNING   REVERSED SCANNING

When someone in a room represented on the left, say, (A or C) looks
toward a monitor on the right (B or D), then their (mirror) image appears
to lock in the same direction. This then complements the situation that
already exists for the up/down directions and produces an overall
consistency of gaze direction for participant and image.

2.4 Recording

2.4.1 Sound recording. From mid-June all discussions were recorded
on a stereo cassette recorder, each channel recording two participants.
This enabled us to play back conferences for more detailed analysis. A
slight drawback with this arrangement using one stereo recorder is that
since two rooms are recorded on each channel, use of the private system
can result in two independent conversations being superimposed.

2.4.2 Private call logging. It was decided that an automatic means
was necessary of recording the use of the private system by participants.
The means adopted was to design an "interface box" to multiplex the
signals representing all the possible private calls or call attempts into

a suitable input for a specially developed program run on an "Apple II" microcomputer. (The circuit details and software for this system are described in detail in Annex A.)

The equipment is easily adaptable to include an extended range of logging such as video switching or timing of speech patterns as well as private channel use.

The information available for those sessions where the logger was in use is a printed record of the exact time duration and nature of each use or attempted use of the private audio channel.

3. SUMMARY OF MAIN FINDINGS

There is a wide and deep body of research knowledge on tele-
conferencing, but remarkably little has been concerned with multipoint
video conferencing, and what there has been has focused on educational
applications. Therefore this research in many ways breaks totally new
ground. It was not known for example whether research findings from
two-person meetings would scale-up to four-person meetings. In addition
the scope of the research, both to generate and test ideas for improving
group effectiveness, necessitated an approach which emphasized breadth
rather than depth of research detail.

In this summary chapter, the main findings of relevance to the DARPA
teleconference program are presented. They encompass results which were
obvious without the necessity of statistical and experimental
verification, conclusions based on more orthodox research procedures, and
strongly held opinions of the research team which can only be partly
substantiated by numerical analysis. Nevertheless they are based on some
1140 man-hours of use of the teleconference equipment by a broad
cross-section of business and professional personnel in meetings lasting
from 40 minutes to a week. The justifications for the findings presented
in summary form here, are given in chapters 5-10 which comprise part II of
this report. In presenting the summary findings, the same sequence will
be adopted as in the detailed chapters of part II, so as to make it easier
for the reader to trace the line of argument.

3.1 Ergonomics and Design

- A flat matrix array of video monitors, with a single camera
  per station (scanning in a reverse direction) is perfectly
  adequate to permit full and effective teleconferencing. It
  permits the ready identification of who is talking to whom in
  a meeting without the need for name-tagging all comments.

- The lack of precise 'eye-contact' between participants,
  partly associated with the use of only one camera per
  station, while noted by some users at the start of
  teleconference sessions, was not found to interfere with the
  progress of the discussion. The only comments made on this
  point after meetings were by some users who found it useful
  to be able to look at another person in the meeting without

risking the occurrence of anxiety-provoking mutual-gaze.

- The reverse scanning of the image cameras was not noticed by participants unless the fact was pointed out to them. It resulted in a much more comfortable meeting.

- A self-view monitor is valuable for keeping meeting participants in camera shot, though it need not necessarily be available all the time.

- An open-audio teleconference sound system was found to provide adequate speech levels in teleconference rooms with only modest treatment for sound absorbency. It resulted in much freer discussion than could have been possible with a voice- or manually-switched conference system.

- The use of separate loudspeakers associated with video monitor images provided sufficient orientation cues to identify the main speaker in a discussion, even when there was no prior familiarity with the normal speaking voice of fellow participants. The inclusion of additional signalling lights as cues to the current main speaker were found not only to be unnecessary, but also intrusive and distracting.

- A video monitor presenting text and graphic information was preferred at a closer viewing distance than the monitors carrying the images of the other participants.

- The control panel with simple, self-illuminating push-buttons laid out in a pattern isomorphic with the monitor array, was found to be easy to use after a short description. There was virtually no learning time involved.

- The control over the destination of the participant's video image, was only used in prolonged meetings on a single task.

3.2 General Impact of Multipoint Video Teleconferencing

- Users found that their meetings held over the teleconference system, compared to their normal experience of face-to-face meetings, were at least as satisfying, more task-oriented, and less time consuming. The individual level of contribution was not thought to be any different from normal.

- When users were provided with just audio teleconferencing and no video image, they were less favourable toward the teleconference. Video appears to increase user satisfaction, and other participants were felt to be more cooperative and friendly in the video conference meetings compared with the audio-only. This added value from the visual channel in teleconferencing is at variance with previous research which saw little value in using video.

- The teleconferencing equipment itself was seen as helpful to the progress of the meeting, rather than distracting.

- The perceived benefits of the teleconference were found to be greater in those tasks involving competition and conflict than in the more cooperative tasks. This is again at variance with the traditional wisdom of teleconference research, which considers conflictual meetings to be unsuitable for teleconferencing.

- Feedback from other members of the group during discussions was reported to be heightened in the teleconferenced meeting compared with face-to-face.

- Groups undertaking cooperative tasks produced better outcomes when other group members were experienced as being more friendly, and when one person felt he himself had greater control over the meeting.

- Attempts to replicate teleconference research on attitude change in two-person communication, showed that substantial shifts of attitude could be achieved in the short term of the discussion, but these rarely produced sustained opinion changes by individual members. Nevertheless, the presence of moderate opinion-holders in a discussion did tend to produce more sustained attitude change than otherwise. Furthermore, agreements reached were not necessarily by a simple process of averaging the individual opinions of the group members. They could involve movement of opinion from, as well as towards a moderate position. Teleconferencing was found not to assist isolated group members (i.e. those holding opinions different to the other three) in persuasive discussions. They

were usually forced to come in line with the majority view.

- Teleconferencing did not facilitate swings toward more extreme opinions. Replication of classical social psychological studies on the 'risky-shift' phenomenon did not produce major movements of the average group opinion either toward more risky decisions or more cautious decisions.

3.3 Decision Enhancement Facilities

- None of the teleconference decision enhancement facilities initially considered were found to produce marked improvements in decision outcomes. However some of the facilities were used extensively and considered beneficial. The lack of demonstrable effects is not surprising considering the variability between the basic capabilities of different groups and the loosely structured ways in which the facilities were introduced.

- The private audio communication channel was used substantially for a range of different purposes including maintaining group morale, seeking alliances, and establishing separate workgroups. It was used more extensively in competitive discussion tasks than in cooperative ones.

- A quarter of uses of the private system were of very short duration (less than 10 seconds) and more concerned with making brief comments. Only 15% of private calls lasted more than 5 minutes, and these usually constituted distinct subgroup activities. The middle range of uses were primarily concerned with the clarification of issues in the general run of the discussion. While the longer duration private calls could instead be established by an outside controller, the use of the facility for short comments suggests that participants do need the spontaneous ability to make immediate and brief personal contacts.

- In extended tasks, some limitation was found with the ability of the private audio system to handle only one link at a time. In larger groups this would be anticipated by appropriate enlargement of the private facility.

- The presence of a natural chairman in the group results in radial style communications, although group members report the discussions to be more democratic than comparable face-to-face meetings. Chairmen were able to exert their influence more in teleconferenced meetings.

- Attempts to create roles within a group by the provision of specific additional facilities were not successful. Giving only one person a control panel and hence exclusive use of the private audio channel did not assist that person to take on a chairman's role. On the other hand the appointment of a group secretary did help groups to reach decisions in a definite time. The matching of technological aids to natural group roles may still be a valuable possibility.

- A stored voice facility to enable participants to record ideas at the time of thought, was considered to be a good idea, but was not used in its initial implementation. Better implementation in more complex and extended tasks may show some value in the facility.

- The capability of making anonymous contributions to a meeting was not expected to be useful by teleconference participants, who claimed that such contributions would lack credibility.

- The use and volume of information during a meeting was found to be bound up with the quality of decision reached. Better decisions were made when information overload was avoided.

- The selection and presentation of information by an outside aide (the session controller) via a central documents camera was found to be acceptable to participants and easy to operate. Such information was generally presented to the group as a whole, and individual requests for information were rare.

- A trial application of the enforcement of an agreed agenda, using an outside aide (the session controller) to prompt throughout a meeting was found to be readily accepted by the teleconference participants, and resulted in the more punctual completion of a meeting. Further extension of this work is required on a greater number of discussions.

3.4 The Effects of Prolonged Teleconferencing

- Teleconferenced meetings and discussions involving the same people, for periods between several hours and a working week, show first that it is possible to sustain this type of interaction for longer than any previous research has shown.

- During teleconferences sustained over four days, meeting effectiveness and efficiency were maintained and there was no measurable fall-off in attention or vigilance.

- This type of prolonged meeting is more tiring than would be expected from a comparable face-to-face pattern of work meetings, but it is not possible to determine whether this fatigue is due to the teleconference itself, or to the higher work rate and more focused activities found in teleconferences. The fatigue was not identified in any of the tasks not on the specific measures of attention, it was only reported by participants at the conclusion of their activity (i.e. on relaxation). It is not yet determined how long this sustained level of activity could be maintained.

- On single sustained tasks used as case studies, greater use was made of audio and video switching by the participants to form subgroups to address parts of the task.

- The video channel of communication is particularly valuable at the start of prolonged teleconferencing. Strategies for establishing an effective work group from participants not previously acquainted, were found to be easy and effective when the video channel was available, but strained and awkward when it was absent.

- There was a general pattern of adaptation to teleconferencing apparent during series of discussions by the same groups held over four days. The video images and communication pattern were reported as becoming increasingly more natural.

- Aggressive behaviour was reported to increase, and friendly behaviour to descrease amongst group members after the second to third consecutive day of teleconferencing. This may be a symptom of stress, or could, more positively, indicate that the group is passing through well-documented phases of development.

4. IMPLICATIONS AND NEW DIRECTIONS

The extensive list of main findings and points presented in the previous chapter shows above all else that multipoint video teleconferencing is a fertile environment in which to hold decision making meetings. Meeting participants readily adapt to the form of interaction, and report that their meetings are more efficient, especially when there is an element of conflict involved. The suspicions discussed in chapter one have been confirmed: the increased 'interpersonal distance' inherent in teleconferencing works to the benefit rather than the detriment of high conflict meetings. A video teleconference system which does not try to emulate face-to-face meetings, can be used for both short and sustained meetings without disruption of normal group processes, and indeed with a general reported improvement over similar face-to-face meetings.

Arising from these simple results is the clear implication that DARPA should continue to examine ways in which the loss of face-to-face fidelity can be used creatively. Going beyond the straightforward teleconference system, some of the additional capabilities provided, which could not be introduced in face-to-face meetings, were found to have value to the meeting participants. The ability to establish a private audio channel between two participants is a facility that had wide and varied application, was readily accepted by the participants, and was found to be used to varying degrees in different types of task.

Two recurrent themes emerging from the attempted application of decision-enhancement aids, are that they have to be simple to use and should be under the control of the participants themselves. The introduction of new ways of conducting meetings encounters resistance unless the benefits are immediately apparent to the would-be users (note, for example, that several different uses were possible for the private audio facility), and they can have immediate success in operating the system. Facilities which involved the participants in having to request services from the controller were not used to any great extent unless the need was particularly strong (e.g. in gaining relevant information via the documents camera). Thus it may be that even high level personnel in crisis decision making situations would not prefer all additional facilities to be handled by a teleconference aide not directly involved in the discussion. Wherever it can be done without imposing heavy

learning requirements, control should be left with the participants themselves.

The research which examined teleconferencing over prolonged periods opens up a particularly rich vein of activity directly relevant to DARPA's requirements. It can be anticipated that real crisis decision making will consist of a series of interlinked decisions taken over an extended period of time. The evidence so far shows that teleconferencing can be sustained for long periods at a time without any deterioration in attention and vigilance beyond that expected for similar activities under normal conditions. It has also been shown that increased meeting efficiency is sustained over these longer sessions. But on the negative side there are preliminary indications that total fatigue does build up as a result, although not to a level that affects meeting performance in the time-scales studied. It is important that the cause of this fatigue is more adequately understood so that some steps might be taken to alleviate its build-up. This might involve shutting-down the teleconference system for brief rest periods, or deliberately injecting some more social element at certain intervals.

This leads naturally into considering the most fruitful way of furthering the aims of DARPA in future research. Two broad avenues of activity are indicated. The first is to continue with the development of new decision-enhancement aids and to refine their implementation and evaluation in decision making tasks. Figure 4.1 and figure 4.2 consider areas in the group decision making process where shortcomings may be anticipated and circumvented with aids built into the teleconference system. Some of these aids have already been tried and tested to some extent in the work reported here. Some need to find ways of implementation within the guidelines just discussed. At some point a precise evaluation of the contribution of aids would need to be conducted within a more rigorous research paradigm. Without this it will be difficult to move away from the subjective judgements used in this report.

The second area of research should concentrate on prolonged meetings, concerned with a single issue and conducted under conditions of stress. The aims of this research would be to gain a better understanding of the limitations of prolonged teleconferencing, and to find ways of

Figure 4.1   SCHEMATIC REPRESENTATION OF THE DECISION-MAKING PROCESS
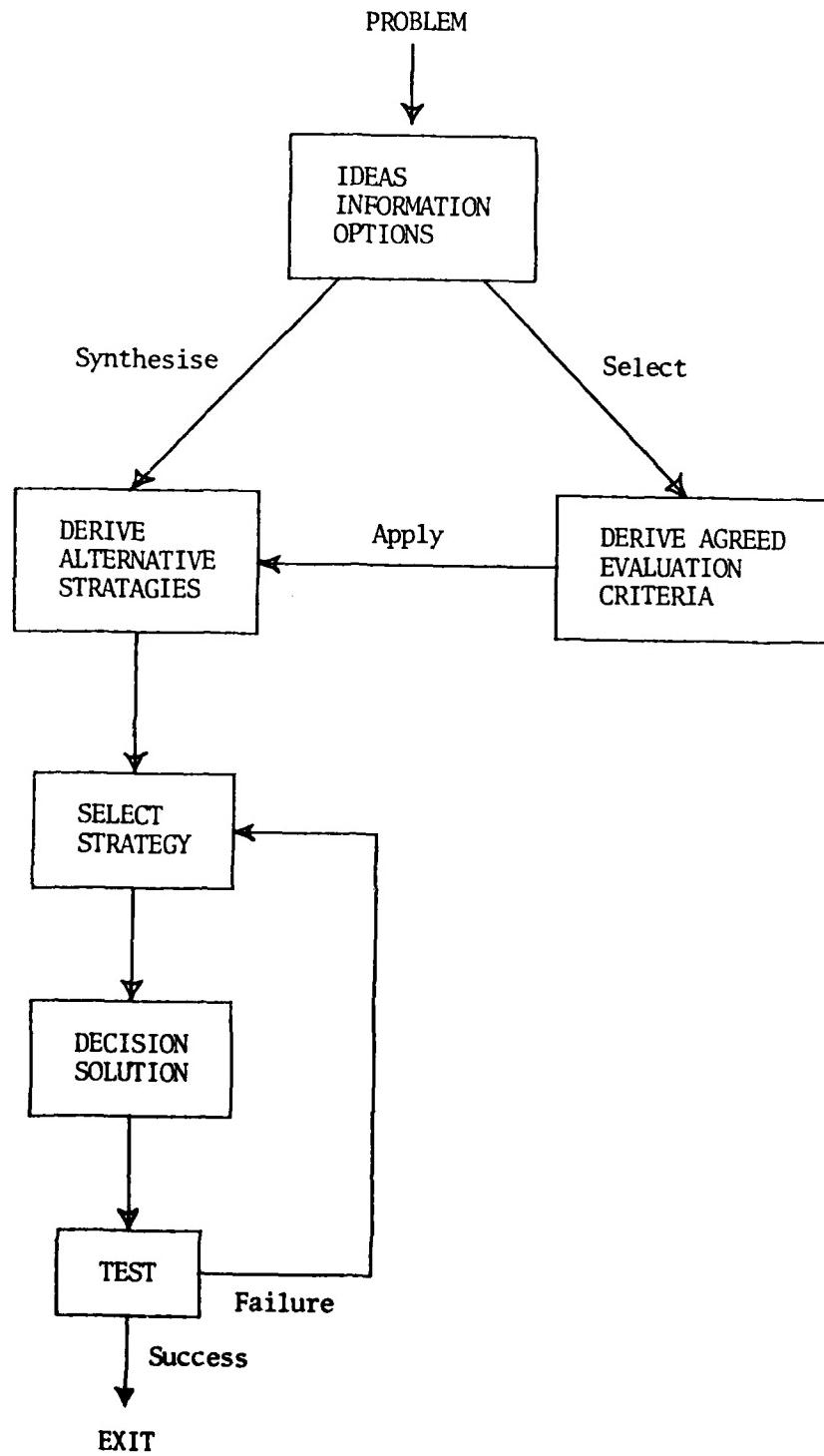
Figure 4.2   Frequent problem sources in group decision-making

Problem	Possible causes	Solutions
Not enough ideas	Group members inadequate	Broaden group aides
	People inhibited from proposing ideas	Allow anonymous input of ideas
	Ideas 'lost' before they can be presented to meeting	Allow ideas input at time of thought
	Insufficient time given to generating ideas	Improve chairmanship, help maintain agenda
	Discussion tangential and unfocused	"
Not enough information available	Critical information not brought into meeting	Improve access to information sources
	Information sources not identified	Have "information expert" available
"Right" information not used	Insufficient information available	Improve access to information sources
	Information overload	Make information timely and selectedly valuable
Evaluation criteria not agreed or specified	Need not recognized	Prompt participants on criteria/decision model, use of evaluator role
	Insufficient time spent on criteria	Chairmanship/agenda maintenance
	Criteria not mutually 'understood' by all members	Operate a 'working dictionary'
Whole strategies not developed	Lack of continuous development of ideas	Chairmanship/agenda maint. subgroups allowed to work 'off-line'
	Gaps in knowledge/ information needed	Access to rapid and wide database
Criteria not applied to strategies	Criteria forgotten or changed	Operation of group memory/evaluator
	Criteria not appropriate to strategy	Improve criteria or strategies or both
	Use of evaluation criteria ignored	Prompt on decision model/ use of evaluator
No agreement on best strategy	Evaluation criteria not consistently applied	Operation of decision model, separate evaluator/team

circumventing any negative effects encountered.

The work presented in this report has broken new ground in teleconference research on many fronts: multipoint video conferencing; teleconferenced group decision making and conflict resolution in realistic evaluable tasks; the introduction of facilities new to any form of real-time teleconference; and the examination of prolonged meetings under teleconference conditions. It is inevitable that the outcomes of such research are a set of valuable signposts rather than an infallible map of the territory. These signposts are encouraging to the aims and objectives of the DARPA teleconference program and it is recommended that as many as possible are explored in further research, in both laboratory settings and in a trial system in the field.